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Power Saver: Intelligent Streetlight Systems Using Fuzzy Logic

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Abstract:
Background*: The energy crisis is one of the main challenges of the modern world. Numerous street light systems consume a significant amount of power.*
Materials, Methods, and Results*: This paper aims to design an intelligent traffic sensing streetlight system, which is composed of Arduino microcontrollers, infrared sensors, and light intensity detectors, and this system tends to reduce energy consumption by considering following two features. Firstly, the fuzzy logic light intensity controller appreciates the presence of ambient light to decide the brightness of streetlight. Consequently, this controller could save energy, particularly in the morning and evening, when the presence of ambient light is prominent. Secondly, this system can comprehend the direction of automobiles, seemed almost new research with uncomplicated hardware, and based on which some forwarding lights are switched on for moving traffic.Thus the projectedschemesaves more energy compared to the existed automated systems, where lights are turned on inboth forward and backward directions of the vehicles.*
Conclusion: *Road management may employ the designated system with simple and inexpensive hardware and software. Therefore, the proposed intelligent streetlight system could be anaugmentationto the existing energy-saving streetlight establishments.*
Key Word*:Streetlight; Intelligent systems; Fuzzy controller; Light intensity control; Energy-saving.*

I. Introduction

Streetlights, which are part of our everyday life, are the source of light adjoining roadways, parking areas, and public spaces[1]. These lights make the street less prone to accident and crime. Besides, road lights provide an excellent and broad view of the road and its surrounding areas to the drivers and the pedestrians[2]. However, the streetlight system consumes a considerable amount of energy. Hence, so many researchers tried to reduce power consumption[3]. They also tried to incorporate automation for better management and fewer wastes of power[4].

Power consumption of traffic illumination is increasing throughout the world[5]. Optimisation of the traffic system has been a significant research area for years. Hoyer and Jumar made use of fuzzy logic (FL) to determine traffic signal status in the last century[6]. Tan KK et al. addressed the problem of intensity-based traffic signal light applying FL[7]. According to the arrival rate and queue size of a vehicle, they determined the extension time of the signal light.

Panjaitan and Hartoyo worked with the same purpose of saving power[8]. Their research was accomplished to minimise the power consumption in domestic buildings. They transformed the indoor and outdoor lighting level to determine essential artificial lighting level via fuzzy control. They reduced the power consumption to the extent of 75%.

Velaga and Kumar attempted to reduce the waste of energy of the street light systems, where they used an automatic LED controller based on sensing the ambient light[9]. Further, Sindhu et al. accelerated the reduction of waste of energy by using motion sensors, in which street lights are switched on if vehicles are present in the road[10]. Nevertheless, their smart light system was confined to one-way traffic. However, sometimes, the lights are turned on later when a person or a car moves onto it. The light should be switch on before the presence of traffic and person to get anencompassing view[11].

This work intended to reduce the human effort by automation, which has been established in previous research, and reduces power waste by firstly, controlling the light intensity by FL because ambient light can serve the streetlight to make the road more lighten in the morning and evening. Therefore, at that time, streetlights can save power by restricting them from glowing fully.Secondly,as far as research is concerned, there is a deficiency of incorporating the direction of automobiles for street illumination in two-way roads. Additionally, streetlights need to be switch on sometime early of traffic presence to give them a broad view only in the forward direction, and this investigation is inclined to facilitate these necessities.

II. Architectures of the Intelligent Streetlight System

This sectiondemonstrates the architecture of the intelligent streetlight system.

The Organisation of Streetlights: The constitutions of the intelligent streetlight system are as follows.

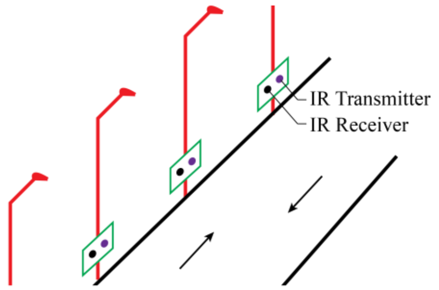

Figure no 1: The organisation of streetlights

The architecture comprises several infrared sensors (IR), a light-dependent resistor (LDR), and some light-emitting diodes (LED). An IR sensor and a light pole (an LED) are grouped. These chunks are placed at one side of the lane, arranged in a specific interval of distances, and connected by wire to reduce the cost[12]. These sensors send the data to the controller whenever a vehicle is identified. Similarly, light poles are connected to the controller and turned on following the controller. A light-dependent resistor (LDR)detects the intensity of ambient light. The controller unit, consisted mainly by an Arduino Uno, commands around six poles of the streetlight.

The Principles of Intelligent Streetlight System: A block diagram in Figure no2 shows the basic principles of the intelligent streetlight system. Sensing unit, Arduino microcontroller unit, and the lighting system constitute the overall structure.

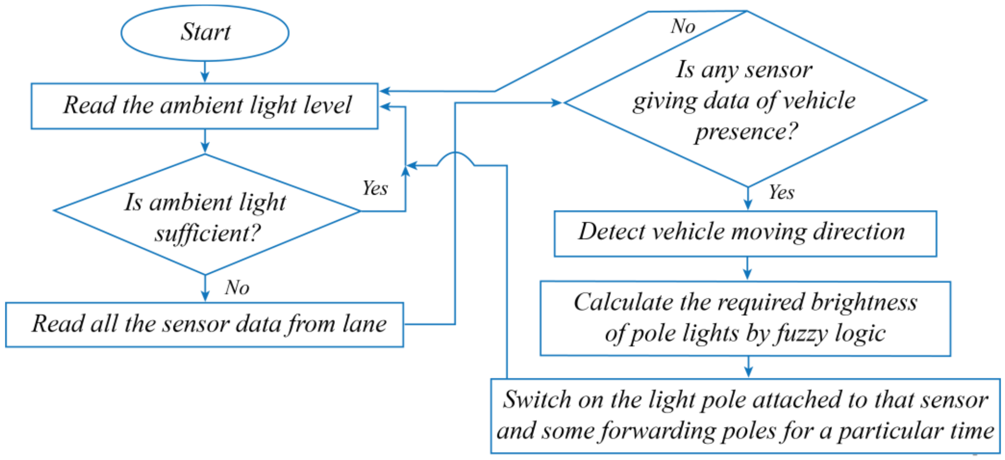

Figure no2: The algorithm of the intelligent streetlight system

The Arduino Uno, based on an ATmega328 microcontroller, consists of 6 analogue inputs, 14 digital input/output pins (only six can be used as PWM outputs), a USB connection, a power jack, an ICSP header, a 16 MHz crystal oscillator, and a reset button. It requires an easyplugging into a computer with a USB cable and facilitates everything needed to affirm the microcontroller[13].

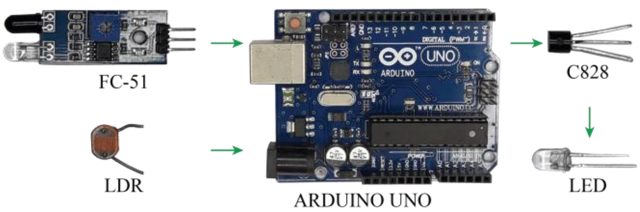

Figure no3: Scheme of data flow in the intelligent streetlight system

Traffic Directions Determination: When a streetlight pole's IR sensor sends the data of traffic presence to the controller, it decides the directions of the vehicle by the following method.

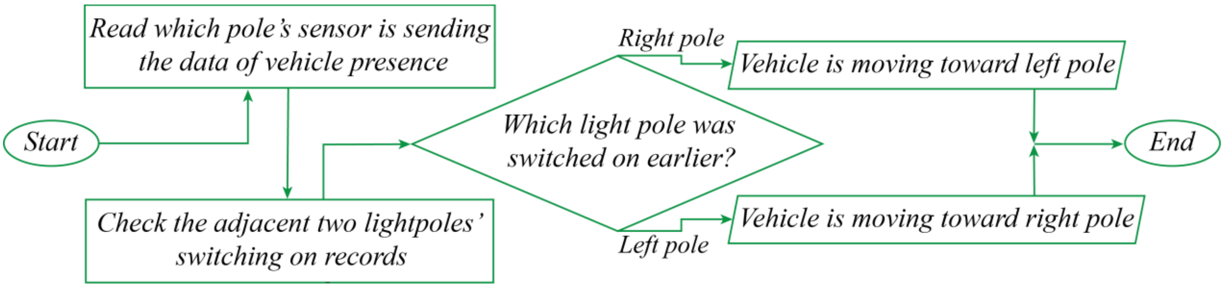

Figure no4: Direction of traffic determination

Arduino includes millis() function, whichreturns the number of milliseconds that have elapsed since the program started, and rendersthe multitasking capabilities. This function makes it possible for the controller to receive data from all the pole's infrared sensors and to send data to all the pole's lights almost simultaneously. The controller also, always, keep the last record of every pole's last switching on time. Observing these records controller can determine the automobile direction by the algorithm in Figure no 4.

Fuzzy Logic Light Intensity Controller: The proposed system uses FL, an AI tool which resembles human reasoning. It functions the intensity of ambient light to the brightness of street lightswimmingly. Consequently, drivers get a constant luminous brightness in the roads. The representation of notation and the mathematical model for the FLight intensity controller is accomplished as follows.

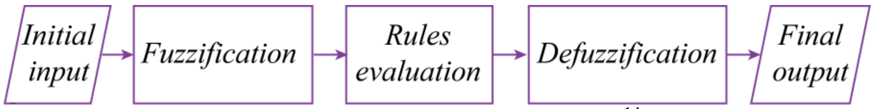

Figure no5: FL light intensity controller[14]

Input: The proposed fuzzy controller has one input, which is the variable *x* and represents the level ofintensity of ambient light in the universe of discourse of [0, 20]. This input data is feed from the street LDR,havingbeen squashed into an interval of [0, 20].

Fuzzification: The crispinput, found from the previous step, is mapped to theintensity level of ambient light, which is consisted of three steps: *Gloomy*, *Cloudy* and *Shiny*. The system will consider the triangular membership function, illustrated in Figure no 6.

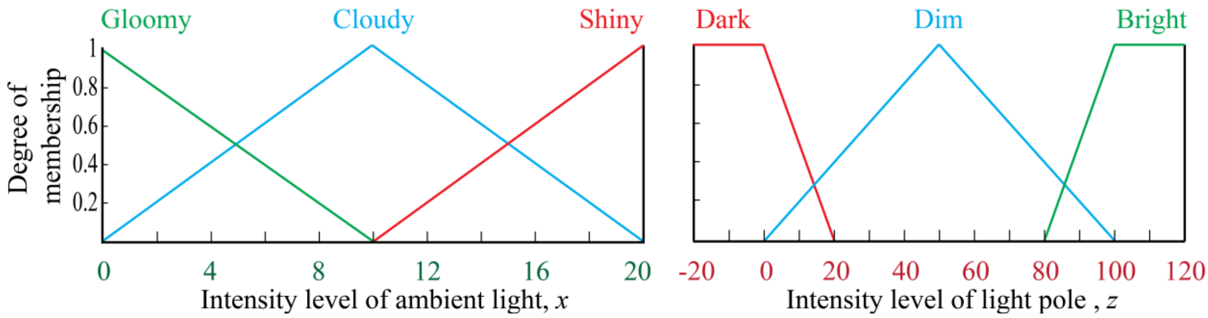

Figure no 6: The inputand output membership functionsof FL

Rules Evaluation: The FL of this system presumes the following rules.Regarding the streetlight intensity, the output membership function has three levels: *Dark*, *Dim* and *Bright* in the universe of discourse of [-20,120]. The light pole's intensity of the proposed system will be a combination of the triangular and the trapezoidal membership function, shown in Figure no 6. Based on the rules in table no 1, the intensity level of ambient light is, further, functioned to the intensity of the light pole.

Table no 1: FL rule bases of the proposed system

Input (Intensity of ambient light)	Output (Intensity of light pole)
Gloomy	*Bright*
Cloudy	*Dim*
Shiny	*Dark*

*Defuzzification:*The centre-of-gravity method has been used in this system[15]. Light Pole's intensity level, evaluated at the abovestep, is converted to a crisp value in the defuzzification process.
Output: The crisp valuez, found from defuzzification, determine the intensity of the light pole, and all the negative values of z correspond to zero intensity.Here, a different level of the streetlight is achieved by pulse with modulation by Arduino Uno.
Experimental Setup: This section presents the hardware and software arrangement of a prototype of the proposed intelligent streetlight system.
Hardware Arrangements: The experimental setup composed of an Arduino Uno as the controller, five 5-mm LEDs as five light poles, five FC-51s as IR sensor modules, and five C828s transistors as switches of LEDs.

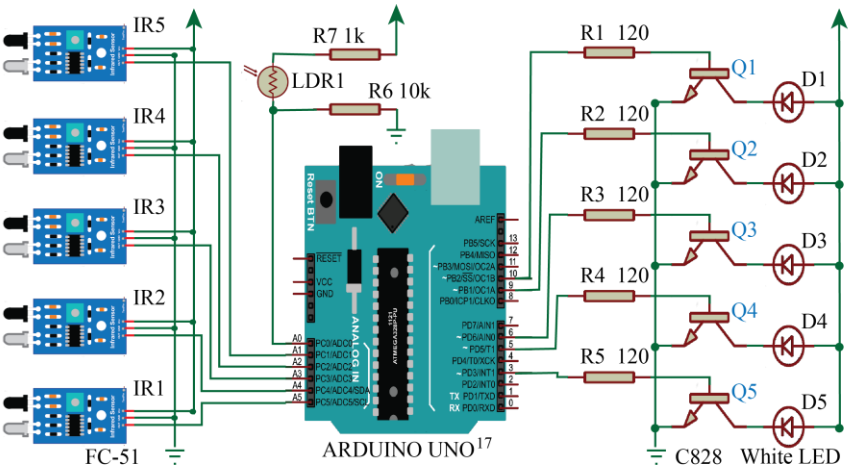

Figure no 7: Circuit diagramof the prototype

IR sensors, laid on the side of the roads, transfer the signal to the controller about the presence of an automobile. An LDR, placed on the drive, feeds data about the intensity of ambient light to the controller[16]. The microcontroller analyses all those signal from sensors and synthesise to perception: where a vehicle is situated, its direction, and how much ambient light is present on the street for a particular moment. Based on this comprehension, the microcontroller commands when, how long, and with how much intensity a streetlight should be turned on.

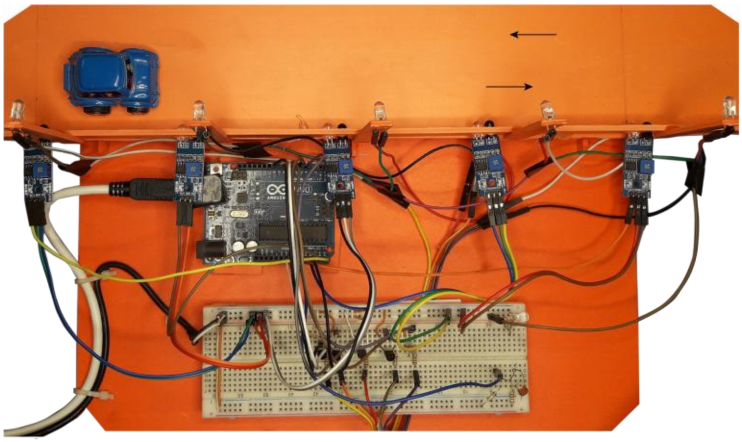
Figure no8: Pictorial view of the experimentalsetupof the prototype

*Software Arrangement:*Following source code constitutes the software portion of the prototype ofthe signified streetlight system.

```
//Start
intpinNo[]={0,1,2,3,4,5};//Pin No, IR Sensors are Connected
intpinVal[6];          //Sensed value, Sensed by IR Sensors
int threshold = 80;    //Threshold for pinvalue
inti=0;                // Counter
intaddTime=1000;//Add extra glowing time for LED, millisecond
unsigned long curTime=0, PrevCurTime=0,difference=0; //These
will be used to keep time track
```

```
if(pinVal[3]<threshold)
    {ledTim11= curTime+ addTime;
      if (ledTim12 <curTime)
          {ledTim12= curTime+ addTime; }
      else ledTim10= curTime+ addTime ;    }

if(pinVal[4]<threshold)
    {ledTim12= curTime+ addTime;
```

```
unsigned long ledTim9=0, ledTim10=0, ledTim11=0,
ledTim12=0,ledTim13=0; //These will be used in Glowing
time controlling for each led
float lightSense=0; //Ambient light intensity
intlightMin=0, lightMid=10,  lightMax=20;//Values of x1 where
Peak value of fuzzy triangle lie.
float centroidOff=-6.66 ,centroidDim=
50,centroidGlow=100;//Centroid of light-pole-intensity areas
float y_dark,y_mid,y_high; //Fuzzy membership value
float brightness;

void setup()
  { pinMode(9,OUTPUT); pinMode(10,OUTPUT);
pinMode(11,OUTPUT);
pinMode(12,OUTPUT);pinMode(13,OUTPUT);  }

void loop(){
        if(curTime-PrevCurTime>2000) {
                lightSense=analogRead(A0);
                if(lightSense>45)lightSense=45;
                if(lightSense<10)lightSense=10;
                lightSense= map( lightSense, 10,45, 0, 20);
                PrevCurTime=curTime;  }

        pinVal[1]= analogRead(A1); pinVal[2]=
        analogRead(A2); pinVal[3]= analogRead(A3); pinVal[4]
        = analogRead(A4); pinVal[5]= analogRead(A5);
        curTime= millis();

        if(pinVal[1]<threshold)//Is vehicle present?
            {ledTim9= curTime+ addTime;
              if (ledTim10 <curTime)
                  {ledTim10= curTime+ addTime; }}
        if(pinVal[2]<threshold)
            {ledTim10= curTime+ addTime;
             if (ledTim11 <curTime)
                {ledTim11= curTime+ addTime; }//Vehicle is
        moving towards led 11
        else ledTim9= curTime+ addTime ;      }//Vehicle is
        moving towards led 9
                if (ledTim13 <curTime)
                    {ledTim13= curTime+ addTime; }
                else ledTim11= curTime+ addTime ;     }

        if(pinVal[5]<threshold)
            {ledTim13= curTime+ addTime;
              if (ledTim12 <curTime)
                        {ledTim12= curTime+ addTime ;} }
        //Finding the Fuzzy membership value of input
        y_dark=0,y_mid=0,y_high=0;
        if(lightSense<lightMid) {
        y_dark= (lightMid-lightSense)/(lightMid-lightMin);
        y_mid=lightSense/lightMid;                    }
          else {y_mid=(lightMax-lightSense)/(lightMax-
        lightMid);
        y_high=( lightSense-lightMid)/(lightMax-lightMid); }

        //Finding the output crisp value
        brightness=(centroidOff*y_high+ centroidDim* y_mid
        + centroidGlow*y_dark)/(y_high+y_mid+y_dark);
        brightness= map( brightness, 1,100, 0, 255);
        if(brightness<0)brightness=0;

        //Switch on the LEDs
        if(ledTim9>curTime)
        analogWrite(3,brightness); else analogWrite(3,0);
        if(ledTim10>curTime)
        analogWrite(5,brightness); else analogWrite(5,0);
        if(ledTim11>curTime)
        analogWrite(6,brightness);  else analogWrite(6,0);
        if(ledTim12>curTime)
        analogWrite(9,brightness);  else analogWrite(9,0);
        if(ledTim13>curTime)
        analogWrite(10,brightness);  else analogWrite(10,0);

}
//End
```

III. Results and Discussion

This study investigated the potential usesthe vehicle direction as the reason to switch on only some forward light poles, to save power. To our knowledge, it is the first study that considers the vehicle direction for two-way road, with a simpleprogramme and simple hardwarein the field of the streetlight.Additionally, the proposed system consider the ambient light for street illumination. Thus it saves power when ambient light can contribute with streetlights to brightenthe roads, especially in the dawn and dusk.

Formerly, as far we are concerned, streetlights were illuminated automatically when a vehicle appeared, but, to get a broad view, drivers need light to turn on earlier. Then lights were turn on both the forward and the backward direction of traffic, but only the forward streetlight serves the driver. Thus switching on the backward streetlight is merely a power loss. This study provides switching ononly the forward streetlights by detecting directions of moving automobiles with elementarycomponents of electronics likeIR sensors and Arduino Uno controllers.

Further, fuzzy logic functions the intensityof ambient light to the brightness of streetlightmore smoothly and accuratelybecause, in the intended work, FL makes the streetlight glow at a brightness level from continuous steps of brightness levels. Whereas, in previous research,the intensity of streetlight was divided into some levels, and the streetlight was bound to choose a step from them. Hence, the transition of street light intensity was not smooth. This work uses power as much as it requires. Therefore, unlike formerexercises, the proposed system saves some energy.

When tested, the specified intelligent streetlight system, constructed prototype, can switch on the streetlights respecting the presence of traffic and its direction automatically, taking account the intensity of ambient light.

IV. Conclusion

The proposed intelligent streetlight system tends to upgrade the previous conventional automated streetlight system by considering ambient lights, which is to affect the intensity of streetlight, and the direction of vehicles because only the lighting of forwarding direction assists the drivers. This two feature, along with the automation, could reduce quite a significant portion of energy waste. Therefore, this endeavour seems to serve the world in the energy crisis to some extent.

References

[1]. Brantingham PL, Brantingham PJ. Criminality of Place: Crime Generators and CrimeAttractors. European Journal on Criminal Policy and Research. (1995);3(3):5-26

[2]. Harbluk JL, Noy YI, Trbovich PL, et al. An on-road assessment of cognitive distraction: Impacts on drivers' visual behavior and braking performance. Accident Analysis & Prevention. (2007);39(2):372-379

[3]. Letu H, Hara M, Yagi H, et al. Estimating energy consumption from night-time DMPS/OLS imagery after correcting for saturation effects. International Journal of Remote Sensing. (2010);31(16):4443-4458

[4]. PatuwoBE, Hu MY. The human factor in advanced manufacturing technology adoption. International Journal of Operations & Production Management. (1998)

[5]. Greening LA, Greene DL, &Difiglio C. Energy efficiency and consumption—the rebound effect—a survey. (2000);28(6-7):389-401

[6]. Hoyer R, Jumar U. Fuzzy control of traffic lights. Paper presented at the Proceedings of IEEE 3rd International Fuzzy Systems Conference. (1994)

[7]. Tan KK, Khalid M, Yusof R. Intelligent traffic lights control by fuzzy logic. Malaysian Journal of Computer Science. (1996);9(2):29-35

[8]. Panjaitan SD, Hartoyo A. A lighting control system in buildings based on fuzzy logic. Telecommunication Computing Electronics and Control. (2011);9(3):423

[9]. Velaga NR, Kumar A. Techno-economic evaluation of the feasibility of a smart street light system: a case study of rural India. Procedia-Social and Behavioral Sciences. (2012);62:1220-1224

[10]. Sindhu A, George J, Roy S, et al. Smart Streetlight using IR sensors. IOSR Journal of Mobile Computing & Application. (2016);3(2):39-44

[11]. Fujii Y, Yoshiura N, Takita A, et al. Smart street light system with energy saving function based on the sensor network. Paper presented at the Proceedings of the fourth international conference on Future energy systems. (2013)

[12]. Wu Y, Shi C, Zhang X, et al. Design of new intelligent street light control system. Paper presented at the IEEE ICCA.(2010)

[13]. Arduino UNO R3.HobbyTronicsLtd. Available: http://www.hobbytronics.co.uk/arduino-uno-r3. (April 15, 2020)

[14]. Saffiotti S. The uses of fuzzy logic in autonomous robot navigation. Soft Computing. (1997);1(4):180-197

[15]. Kim D, Choi YS, Lee SY.An accurate COG defuzzifier design using Lamarckian co-adaptation of learning and evolution. Fuzzy Sets and Systems. (2002);130(2):207-225

[16]. Vegni AM, Biagi M, Cusani R. Smart vehicles, technologies and main applications in vehicular ad hoc networks. IntechOpen Limited. (2013);3-20

[17]. Syed Zain Nasir. Arduino UNO Library for Proteus. Available: https://www.theengineeringprojects.com/2015/12/arduino-uno-library-proteus.html.(May 09, 2020)